A STUDY OF THE LAKE TROUT POPULATION OF FISH LAKE, UTAH DURING 1989-2002

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ABSTRACT

Fish Lake is one of the most popular sport fisheries in the state, supporting three resort marinas and drawing thousands of anglers annually. Lake trout *(Salvelinus namaycush)* were first stocked in Fish Lake in 1900, and while other species are more readily caught, the possibility of catching a trophy fish draws many anglers to the lake each year. Concern about the status and future of the lake trout population arose when a decline in the abundance of forage fish became apparent in the mid-1980s. The catch of Utah chubs *(Gila atraria)* and rainbow trout *(Oncorhyncus mykiss)*, the traditional forage of lake trout in Fish Lake, declined to their lowest recorded levels in the early 1990s. As a result, a study was initiated to determine the cause of these declines and document the current status of the lake trout population. Estimates of lake trout abundance, exploitation, growth rates, and food habits were generated. Lake trout in Fish Lake are relatively abundant, while primary forage species (Utah chub and rainbow trout) are limited. Chub numbers declined following an illegal introduction of yellow perch, and rainbow trout are limited by annual stocking. Smaller lake trout (<20 inches) consume primarily aquatic insects, while larger individuals (>20 inches) convert to a fish diet (primarily rainbow trout). However, it is clear that many lake trout do not convert to a fish diet and remain at smaller sizes compared to their piscivorus counterparts. In addition, smaller lake trout exhibited low condition, while larger fish displayed high condition. The relatively high number of lake trout and limited forage created a bottleneck where few fish are found between 21 and 28 inches. To reach larger sizes, lake trout must convert to a piscivorus diet. Individual fish that squeeze through this bottleneck quickly grow to trophy size. However, many smaller lake trout remain on invertebrate diets for their entire lives, some reaching old age. A change in fishing regulations to allow additional harvest of small lake trout may reduce densities, improve lake trout growth and condition, and allow relatively more fish to reach a trophy size. However, the consequences of increasing the number of trophy lake trout on the sport fishery and to the entire fish community are unknown.

INTRODUCTION

Fish Lake is located in south-central Utah, approximately 40 miles southeast of Richfield (Figure 1) at an elevation of 8,843 feet. The lake covers approximately 2,500 acres, has a mean depth of 55 feet, and a maximum depth of 117 feet. In addition, Fish Lake provides one of the most popular fisheries in the state, supporting three resort marinas and yielding between 80,000 and 100,000 angler hours annually. At the same time the lake regularly produces catch rates of over 1 fish per hour. The fishery does well, in part, because the water is relatively productive. Littoral areas of the lake are covered with thick weed beds that extend to a depth of approximately 35 feet.

The fish community in Fish Lake has changed substantially since the late 1800s when cutthroat trout and mottled sculpin were the only fish present. By the 1940s both species were found in relatively small numbers (Hazzard 1935, Sigler 1953), and by the 1970s native cutthroat trout were all but extirpated from Fish Lake. Mottled sculpin are presently found on rare occasions, possibly because they are difficult to sample.

Introductions of non-native trout and salmon, accompanied by illegal introductions of other species were, in part, responsible for the loss of native fishes. Between 1899 and 1984 a total of 10 species or strains of trout and salmon were stocked in Fish Lake. At the same time, 4 species of non-game fish, yellow perch, and largemouth bass were illegally introduced. Early introductions to the fishery included brook trout (1899), lake trout (1900), rainbow trout (1915), Atlantic salmon (1924), chinook salmon (1925), coho salmon (1926), and chum salmon (1939) (Popov and Low 1950, Sigler 1953). Redside shiners were first found in the lake in 1934, while Utah chubs were found in about 1923. It remains unclear whether the chubs were stocked as a forage fish or were illegally introduced to the lake (Madsen 1937).

Prior to the introduction of Utah chubs, the fishery at Fish Lake was characterized by relatively high numbers of fast growing brook and rainbow trout (Hazzard 1935, Madsen 1937). Rainbow trout regularly reached two pounds with some individuals up to nine pounds. Following the introduction of Utah chubs the number and size of rainbow trout decreased. At approximately the same time, brook trout stocking was discontinued and these fish slowly disappeared from the fishery (Sigler 1953; Shirley 1972).

Other introductions included brown trout (1946), kokanee salmon (1961), and splake (1984). Largemouth bass were found in 1951, likely from an illegal introduction, but they have not been seen since. Yellow Perch were introduced illegally in the early 1960s and have since become abundant. Utah suckers, native to the Sevier River and Great Basin, are also common in Fish Lake, but it is uncertain how or when they were introduced (Sigler 1953; Shirley 1972). In addition, Carp from an illegal introduction were found in the early 1980s and continue to persist in low numbers.

At present the fish community is dominated by stocked rainbow trout, yellow perch, and Utah chub, while lake trout, stocked splake, and Utah sucker are relatively common. Brown trout and

redside shiners are occasionally sampled during trend netting surveys, but brook trout, carp and mottled sculpin are rarely seen at Fish Lake.

In addition, changes in aquatic plants have been documented at Fish Lake during the past century. While plants have always been abundant in the lake, changes in species composition have occurred. Early reports document extensive beds of vegetation covering the bottom of the lake out to a depth of approximately 40 feet (Hildebrand and Towers 1927). By the 1990s, however, this carpet of vegetation had changed to a dense forest of aquatic plants that had grown from the substrate to the surface, nearly covering the littoral zone. In 1992, investigators identified a major contributor of this change as Eurasian water milfoil, an exotic nuisance species. Currently, this plant dominates much of the littoral zone of the lake.

Introductions in fish species and changes in plant communities at Fish Lake have led to changes in invertebrate populations. Early lake studies documented large numbers of amphipods or "scuds" in the lake and in the diet of trout. Hildebrand and Towers (1927) and Hazzard (1935) reported that amphipods were the most common food item in trout stomachs. Other important food items included zooplankton, aquatic insects, and algae. In addition, Madsen (1937) reported these food organisms to be the most prevalent food items in the stomachs of Utah chubs. More recently, Shirley (1972) documented that zooplankton, algae, and fish were the most common items in the stomachs of rainbow trout and that amphipods made up less than one percent of the rainbow trout diet. To supplement the forage of trout, mysis shrimp (native to Canada) were introduced from Colorado in 1970 (Bangerter 1970).

From their first introduction in 1900 until this study, lake trout have successfully occupied the lake. By 1910, anglers were reporting "good catches" of lake trout and natural reproduction had been reported (Popov and Low 1950). Despite recruitment of wild fish, a supplemental stocking program was established. While unrecorded plants may have occurred between 1910 and 1940, recorded stockings routinely occurred between the 1940s and 1991 (Table 1). Since 1991 the lake trout fishery has been supported entirely by natural reproduction.

Historically, lake trout at Fish Lake provided an important brood-stock and egg source for production of lake trout and lake trout hybrids at Utah state fish hatcheries. However, in 1997 a lake trout brood stock was fully established at the Egan hatchery near Bicknell, Utah. Consequently, October spawning operations were discontinued at Fish Lake and a monitoring program, designed to follow trends in lake trout populations, was established. Concern about the status and future of the lake trout population arose when a decline in Utah chubs became apparent in the mid-1980s. Utah chubs, the traditional forage of lake trout, became less abundant in pelagic areas, while harvests of rainbow trout, an alternate lake trout forage, and the primary sport fish, also declined (Berg and Hepworth 1990). These declines coincided with increased numbers of yellow perch. It is believed that the illegal introduction of perch in the 1960s set up a chain of events that led to the decline of Utah chubs and a coinciding switch of lake trout predation from Utah chubs to rainbow trout.

This study was initiated in 1989 to determine the dynamics of the Fish Lake fish community and the status of the lake trout population. Study objectives included:

1. Document natural reproduction of lake trout and estimate its contribution to the Fish Lake population.

2. Estimate the population size of lake trout ≥20 inches in length.

3. Evaluate the relative abundance of adult lake trout (fish that are sexually mature) during the 1990s and compare to historical records.

4. Estimate angling pressure and harvest of lake trout at Fish Lake.

5. Determine the current diet of lake trout in Fish Lake.

6. Document current growth, condition, and size structure of the lake trout population in comparison with previous reports.

7. Evaluate trends between 1991 and 2002 in relative abundance of lake trout forage fish, including: rainbow trout, Utah chub, yellow perch, and Utah sucker.

METHODS

All lake trout stocked in 1989 and 1991 were marked with fin clips to distinguish them from naturally-reproduced fish. Lake trout stocked in 1989 were marked with an adipose clip (AD), while lake trout stocked in 1991 were marked with a right pelvic clip (RP). In addition, 173 lake trout were tagged and released during the 1991 and 1992 egg take operations (Table 2). Tags identified individual fish by number, length, and weight at the time of release.

The majority of lake trout observed during this study were captured using experimental gill nets set during spawning seasons in October of 1993-1998, 2000 and 2002. Additional fish were captured during spring trend netting surveys in May of 1991-2002, or were examined during creel surveys conducted in 1992 and 1998.

Nets set in October were 100 feet long by 6 feet deep with 2 inch mesh. These nets were used to collect spawning lake trout and were set over spawning areas usually in two sets of four (Figure 1). Nets were pulled every 1.0 - 1.5 hours to minimize lake trout mortality. Lake trout were sexed, measured, checked for marks, and released. In addition, the stomachs of lake trout mortalities were examined to determine lake trout food habits. Food items were identified, and placed in one of 9 categories (Table 6), and then reported as percent occurrence.

Experimental gill nets of variable mesh sizes were set overnight during May primarily to monitor trends in abundance of other sport fish. These nets were 125 feet in length by 6 feet deep and consisted of five panels 25 feet in length with mesh sizes of ¾, 1, 1¼, 1½, and 2 inches. Sets generally consisted of 3 inshore floating nets and 3 inshore diving nets. All lake trout captured during May surveys were identified, checked for marks, and then weighed and measured. The stomachs of lake trout mortalities were examined to collect food habit data.

Forage fish abundance was monitored by implementing annual forage fish data collections in 1991. These surveys were conducted in mid-July using two experimental gill nets from May surveys and two 60 foot gill nets with mesh sizes of ½, ¾, and 1 inch. Nets were set in six feet of water and extended through the weed beds and into deeper water. All captured fish were identified and enumerated, while all trout and a sub-sample of 50 individuals from each forage species were measured and weighed.

Creel surveys were conducted from January through October of 1992 and 1998. Creel data were collected using standard creel survey procedures (Thomas and Chamberlain 2000). All trout were identified, measured to the nearest millimeter, and checked for marks. During 1992, the stomachs of harvested lake trout were examined to determine lake trout food habits.

To estimate exploitation and abundance of lake trout a mark-recapture study was conducted. A sub-sample of 173 tagged lake trout were held for 24 hours in live cages to determine tagging survival and adjustments were made to the data accordingly. A reward was offered for the return of tags from harvested lake trout, while a creel survey was conducted from January through October of 1992. Recaptures and the proportion of marked to unmarked fish were observed during the 1992 creel survey and during the 1992 May and October gill-net surveys. Estimates of the number of lake trout > 20 inches were calculated from mark recapture data. Percent tag returns were used to determine exploitation rates for various sizes of lake trout, while catch rates of fall-spawned lake trout were used to monitor trends in relative abundance.

Lake trout growth rates were determined by comparing recapture lengths with stocked and/or released lengths, while lake trout size structure and condition were assessed using length-weight data from gill-netted and creeled lake trout.

Two methods were used to assess the natural reproduction of lake trout in Fish Lake: (1) egg netting (Horns et al. 1989) and (2) mark-recapture. Gangs of 24 egg nets were set on the lake bottom from late September to early November. Gangs were connected to the shore with nets beginning at the outside edge of the weed beds and extending at an oblique angle into deeper water. The maximum depth of egg nets was decreased in 1992 from 60 feet to 40 feet because it was thought that lake trout were not spawning at the maximum depth used in 1991. Three gangs (72 nets) were recovered in 1991 and two gangs (48 nets) were recovered in 1992. Finally, to evaluate natural reproduction of lake trout we examined the ratio of marked (stocked) to unmarked (wild) fish in creel returns and in fall spawning surveys.

RESULTS

Natural Reproduction

Despite discontinued stocking of lake trout, substantial recruitment of small fish to the population continued. Over 97% of all lake trout captured during fall spawning surveys from 1994 to 2002 did not exhibit fin-clips (Table 3).

During 1998, for the first time since beginning the evaluation, we sampled the west shoreline, as well as the east shoreline. It was believed that stocked fish might return to the west shore, where they were first stocked, to spawn. During the 1998 survey marked fish made up 35% of all lake trout captured on the west shore, while only 5% of all lake trout sampled on the east shore were marked (Table 3). It appears that planted lake trout did return to the area where they were first stocked. However, the west shore has also historically attracted fewer numbers of spawning lake trout and consequently, only 19% of all sampled lake trout were captured on the west shore. Regardless of when or where the data were collected, stocked lake trout did not contribute substantially to the fishery.

Likewise, lake trout observed during the 1992 and 1998 creel surveys were predominately wild fish. In 1992, 79% of all harvested lake trout were wild, while 75% of all lake trout observed during the 1998 survey were wild.

One egg was collected in egg nets during 1991 and seven eggs were collected during 1992, indicating that lake trout were spawning at egg-netting sites. In addition, some eggs were viable with developing embryos.

Population Estimates and Relative Abundance

Population estimates were calculated during 1991 for lake trout > 20 inches (Table 4). The best estimate of population size was 1,100 lake trout, with 95% confidence limits ranging from 499 to 2,519 fish. This amounts to about 0.44 large lake trout per acre. Trend analyses of lake trout catch by year showed recent increases in abundance of small lake trout between 15 and 24 inches (Figure 2).

Growth Rates, Size Structure, and Condition

Growth rates among individual fish were highly variable (Figure 3). Age 9 lake trout, stocked in 1991 and recaptured in 2000, ranged in size from 15 to 33 inches. Mean growth rates for various size groups ranged from 1.4 to 2.8 inches per year. The highest growth rates occurring in fish from 25 to 30 inches (Table 5 and Figure 4). Growth slowed after fish reached 35 inches.

Returns of marked fish established that some lake trout were sexually mature as early as age 5 and at lengths as small as 15 inches. However, most individuals did not spawn until age 6 or 7 at an average size of 19 to 20 inches. By age 9 a few exceptional fish reached 30 inches in length, while the majority of marked lake trout were still less than 20 inches.

Data from the three most recent surveys (1998, 2000, and 2002) were combined into one graphic to depict the size structure of the current population (Figure 5). In general, the distribution was bimodal. Small individuals were most abundant with a slight increase in the frequency of larger individuals. Relatively few fish were captured between 22 and 29 inches.

Smaller lake trout exhibited much lower condition than larger lake trout (Figure 6), with the highest condition occurring in lake trout > 30 inches.

Lake Trout Diet

Lake trout began consuming forage fish when they reached 18 inches in length (Table 6). By the time lake trout reached 25 inches they switched to an entirely piscivorus diet. Seventy-one percent of all stomachs that contained identifiable fish contained rainbow trout, while 29% contained Utah chubs. Only rainbow trout were identified in the stomachs of fish > 25 inches. The stomachs of lake trout less than 20 inches in length were dominated by invertebrates; primarily mysis shrimp and aquatic insects.

Forage Fish Trends

Forage fish trend-netting catch rates were variable. Consequently, changes in the abundance of these fish were difficult to demonstrate (Table 7 and Figure 7).

Angler Exploitation and Harvest

Based on tag returns, an estimated 12% of lake trout were harvested by anglers during the first year post-tagging, while an additional 5% were harvested the following year (Table 8). When this exploitation rate is applied to the 1991 population estimate of 1,100 lake trout, an estimated harvest of 85 to 428 lake trout occurred in 1992 and 1993. These numbers were comparable to recent creel surveys. An estimated 380 and 732 lake trout were harvested in 1992 and 1998 respectively (Berg 1993; Chamberlain and Hepworth 1998).

DISCUSSION

Lake trout successfully spawn at Fish Lake and natural reproduction is currently supporting the lake trout fishery. Progress reports compiled during the late 1960s cited small numbers of unmarked lake trout in gill net and creel surveys (Bangerter 1968). These fish were thought to be the result of natural reproduction. Still, it was believed that most of the lake trout were the product of stocked fish. Consequently, nearly 1,250,000 lake trout were stocked into Fish Lake from 1944 to 1991 (Table 1). However, by 1998 75% of all lake trout harvested at Fish Lake were wild fish, and fall spawning samples indicated that more than 95% of all spawning adults were wild fish.

The 1992 population estimate of adult lake trout at Fish Lake (0.44 fish per acre) is comparable to those observed at other waters. Healey (1978) reported densities of mature lake trout from six Canadian waters between 0.09 and 1.13 fish per acre, while Burr (1992) reported densities of 0.12 to 6.58 adult lake trout per acre from seven Alaskan waters.

Gill-net catch rates of spawning lake trout have more than doubled since 1992 (Figure 2), with most of this increase resulting from fish between 15 and 25 inches in length. It is unclear, however, whether this increase represents new recruitment to the population or simply a stockpiling of smaller fish unable to reach larger sizes.

Growth of individual lake trout is highly variable. Highest growth rates were observed for lake trout 25 to 30 inches in length. A review of the food habits of lake trout at this size reveals that these fish are entirely piscivorus. At age nine, seven of the recaptured lake trout from the 1991 stocking were less than 20 inches, while three were between 20 and 25 inches, and seven were > 25 inches. It appears that some individuals never convert to a fish diet and consequently never reach lengths > 22 inches.

We found relatively few lake trout between 21 and 30 inches. By contrast, 1979 length-frequencies were dominated by lake trout between 25 and 35 inches (Figure 5). Our study found that lake trout can grow from 20 to 30 inches in < 5 years and then spend the remainder of their lives between 30 and 40 inches. In addition, the high exploitation rate (16%) of lake trout at this size could potentially remove 60% of all individuals before they reach 30 inches. Even more important, a lack of adequate forage may prevent some lake trout from exceeding 20 inches in length. Donald and Alger (1986) reported that inadequate forage prevented mature lake trout in a Canadian lake from reaching even one pound.

Previous Fish Lake studies have found lake trout growth rates to be relatively high (Figure 8). In 1956 Bulkley (1960) found that age 5 Fish Lake lake trout were 19 inches in length, and by age 10 these same fish were 31 inches in length. In comparison, we found that mean length had decreased from 19 to 17 inches at age 5 and from 31 inches to < 25 inches at age 10. Further, Bulkley (1960) documented mean growth rates for small lake trout in excess of 4 inches per year compared with 1.4 inches per year in the current study.

Condition of large lake trout (>30 inches) was similar to, or greater than, that observed in 1979 (UDWR), while condition of smaller lake trout decreased (Figure 6). Diet studies at Fish Lake (Madsen 1937; Bulkley 1958; Shirley 1972) found that rainbow trout and Utah chub were the predominant food items in lake trout stomachs. Declines in condition of 20 to 25 inch lake trout between 1979 and 1992 are likely correlated to declines in both Utah chub and rainbow trout numbers during that same time.

Lake trout > 20 inches currently consume almost exclusively rainbow trout and Utah chub. These results are similar to those noted by Madsen (1937) who found that lake trout under two pounds preferred Utah chubs, while lake trout over two pounds consumed rainbow trout. Curiously, no yellow perch were found in lake trout stomachs, yet yellow perch were the second most numerous fish captured during recent forage fish surveys. It appears that either yellow perch are not available to lake trout or that lake trout prefer other forage species. By comparison, splake are more often found in the littoral areas of the lake than lake trout and are known to consume yellow perch.

The consumption of rainbow trout by lake trout is particularly troubling. Madsen found that by volume rainbow trout comprised 67 % of the lake trout diet. In Fish Lake there are an estimated 1,100 (499-2,519) lake trout > 20 inches, each consuming somewhere between 1% and 4% percent of their body weight per day (Eby et al. 1995 and Rottiers 1993). At these rates, it requires 8,000 to 24,000 pounds of forage per year to maintain the lake trout population. The UDWR currently stocks approximately 29,000 pounds of rainbow trout annually. To reduce the

impact of lake trout predation on rainbow trout, the mean size of stocked rainbow trout was increased from 5 to 10 inches.

As previously noted, lake trout between 18 and 24 inches switch from a diet of insects and zooplankton to one dominated by forage fish. However, it is apparent that not all lake trout in Fish Lake are able to make the transition to a piscivorus diet. Limited forage fish populations and the stocking of larger rainbow trout have likely aggravated the bottleneck in lake trout growth.

We found comparisons of lake trout exploitation rates and harvest estimates, measured by different techniques, to be fairly consistent. A harvest estimate of 984 fish is equivalent to a yield of 0.38 lbs/acre and an an exploitation rate of 12%. This falls within normal rates for lake trout in other waters (Healey 1978). Healey's research suggested that yields over 0.45 lbs/acre may not be sustainable, while Burr (1992) documented yields of adult lake trout (≥18 inches) of nearly 3.0 lbs/acre for selected Alaskan waters. Current exploitation rates at Fish Lake do not appear to be excessive.

MANAGEMENT IMPLICATIONS

It is clear that lake trout are self sustaining in Fish Lake. It is also apparent that numbers of lake trout between 15 and 20 inches have increased in recent years. We found that lake trout over 20 inches in length require a piscivorus diet if growth is to continue. Yet, the abundance of Utah chubs, the preferred forage for lake trout of this size, has decreased since the proliferation of yellow perch in the early 1990s. Harvest and exploitation have been fairly constant over time, while mean growth rates have decreased and individual growth rates are extremely variable. Growth rates and condition of small lake trout are low.

Management actions could be taken in an attempt to improve forage conditions and the growth of lake trout. More liberal fishing regulations could be imposed to reduce densities of small lake trout, thus allowing a more economic use of available forage. However, the impact this might have on spake and rainbow trout stocking programs and sport fisheries is unclear.

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Table 1. Reported stocking of lake trout in Fish Lake from 1900 through 1991.

Year	Number stocked	Size		
		Number/pound	MM	Inches
1900	400	Fry	---	---
1905	?	Fry	---	---
1944	72,000	?	---	---
1952	36,000	?	---	---
1953	33,250	148	---	---
1954	32,315	115	---	---
1956	43,000	647	---	---
1957	2,366	182	---	---
1958	6,500	80	---	---
1959	14,879	147	---	---
1960	35,908	191	---	---
1966	54,760	185	69	2.7
1967	13,500	60	100	3.9
1968	100,000	66	97	3.8
1969	27,266	50	106	4.2
1972	42,780	69	95	3.8
1973	67,650	63	98	3.9
1974	51,949	35	119	4.7
1975	80,032	59	100	4.0
1976	46,718	10	181	7.1
1977	75,075	55	103	4.1
1979	33,592	64	98	3.9
1980	50,000	50	106	4.2
1981	49,611	69	95	3.8
1982	124,865	44	111	4.4
1983	39,674	24	135	5.3
1985	10,012	18	149	5.9
1986	19,985	26	132	5.2
1987	24,635	19	146	5.8
1989	37,228 *	23	137	5.4
1991	20,070 *	6	215	8.5
Mean	41,534	92.8	119.6	4.7

* Lake trout were marked with an adipose clip in 1989 and a right pelvic clip in 1991.

Table 2. Lake trout tagged and released at Fish Lake during 1991 and 1992.

Size Group (in)	Number Tagged	% Surviving (24 hr holding)	Estimated Number Surviving
		1991	
20-24	42	67	28
25-29	27	83	22
30-34	33	100	33
35-39	39	83	32
40-44	7	100	7
		1992	
20-24	1	67	1
25-29	4	83	3
30-34	14	100	14
35-39	6	83	5
40-44	0	100	0
		Total	
20-24	43	67	29
25-29	31	83	25
30-34	47	100	47
35-39	45	83	37
40-44	7	100	7
All	173	84	145

Table 3. Occurrence of stocked lake trout in fall spawning samples 1994-1998, 2000, 2002.

Year	Shore	Size of marked lake trout (in)	Number (percent) of similar size lake trout				
			Unmarked	AD	RP	All clips	Total fish
1994	East	15-21	761 (99.6)	2 (0.3)	1 (0.1)	3 (0.4)	764
1995	East	15-21	315 (98.7)	2 (0.6)	2 (0.6)	4 (1.3)	319
1996	East	15-21	584 (98.8)	6 (1.0)	1 (0.2)	7 (1.2)	591
1997	East	15-21	287 (98.0)	2 (0.7)	4 (1.3)	6 (2.0)	293
1998	East	15-30	237 (94.8)	2 (0.8)	11 (4.4)	13 (5.2)	250
	West	15-30	39 (65.0)	1 (1.7)	20 (33.3)	21 (35.0)	60
2000	East	15-33	550 (96.5)	3 (0.5)	17 (3.0)	20 (3.5)	570
2002	East	18-35	215 (94.7)	2 (0.9)	10 (4.4)	12 (5.3)	227
Mean			427 (97.3)	3 (0.7)	9 (2.1)	12 (2.7)	439

Table 4. Mark-recapture population estimates for lake trout ≥20 inches total length at Fish Lake, tagged October 17, 23, 1991, and recaptured October 5-8, 1992.

Collection Method	Total Marked Fish Released	Total Fish Observed During Recapture	Number of Recaptured Fish	Population Estimate (95% C.I.)
Creel Survey	145	8	1	334 (36-683)
Gill Netting	145	79	5	1,173 (504-2,799)
Combined	145	87	6	1,100 (499-2,519)

Table 5. Growth rates (inches/year) of tagged and fin-clipped lake trout re-captured at Fish Lake from 1992 to 2002.

Size Group (in)	Mark							
	Adipose		Right Pelvic		Tagged		All	
	No.	Growth	No.	Growth	No.	Growth	No.	Growth
15-19	7	1.5	29	1.4	0	0	36	1.4
20-24	7	1.9	11	1.9	2	1.0	20	1.8
25-29	0	0	12	2.4	3	2.3	15	2.4
30-34	2	2.3	8	2.9	16	1.1	26	1.7
35-39	0	0	2	3.2	34	0.4	36	0.6
Total	16	1.8	62	1.9	55	0.7	133	1.4

Table 6. Percent frequency of occurrence of food items in the diet of lake trout at Fish Lake during 1992 (RBT = rainbow trout, UTC = Utah chub, UNK = unknown fish, MYS = mysis shrimp, AMP = amphipod, AI = aquatic insect, TI = terrestrial insect).

Size group (in)	Stomachs examined			Percent of stomachs with food that contained									
				Fish				Invertibrates					
	Total	Empty	With food	RBT	UTC	UNK	Total	MYS	AMP	AI	TI	Total	Debri
10-14	1	0	0	0	0	0	0	100	0	100	0	100	0
15-19	24	10	14	0	0	7	7	50	21	43	14	97	14
20-24	9	1	8	13	13	63	75	25	25	25	13	63	0
25-29	3	0	3	67	0	67	100	0	0	0	0	0	0
30-34	2	0	2	50	0	50	100	0	0	0	0	0	0
35-39	3	0	3	67	0	33	100	0	0	0	0	0	0
Total	42	11	31	19	3	32	48	32	16	29	10	61	6

Table 7. Forage fish abundance in July littoral gill-netting samples 1991-2002 (no samples were collected in 1997), and May trend netting samples (YLP = yellow perch, UTC = Utah chub, RBT = rainbow trout, UTS = Utah sucker).

	Number collected per net-night			
	July Forage Netting		May Trend Netting	
Year	YPH	UTC	RBT	UTS
1991	32	289	10	10
1992	28	92	14	14
1993	30	61	22	8
1994	40	54	11	8
1995	53	43	21	7
1996	51	50	26	4
1997	N/A	N/A	14	22
1998	90	55	12	12
1999	87	63	16	13
2000	43	85	19	39
2001	16	61	13	22
2002	63	92	11	27
Mean	48.5	85.9	15.8	15.5

Table 8. Angler exploitation rates for lake trout at Fish Lake during 1992.

Size Group (inches)	Estimated Number of Fish Surviving Tagging (1991)	Number of Tag Returns	Exploitation Rate (%)
20-24	28	4	14
25-29	22	4	18
30-34	33	4	12
35-39	32	1	3
40-44	7	1	14
Total	120	14	12

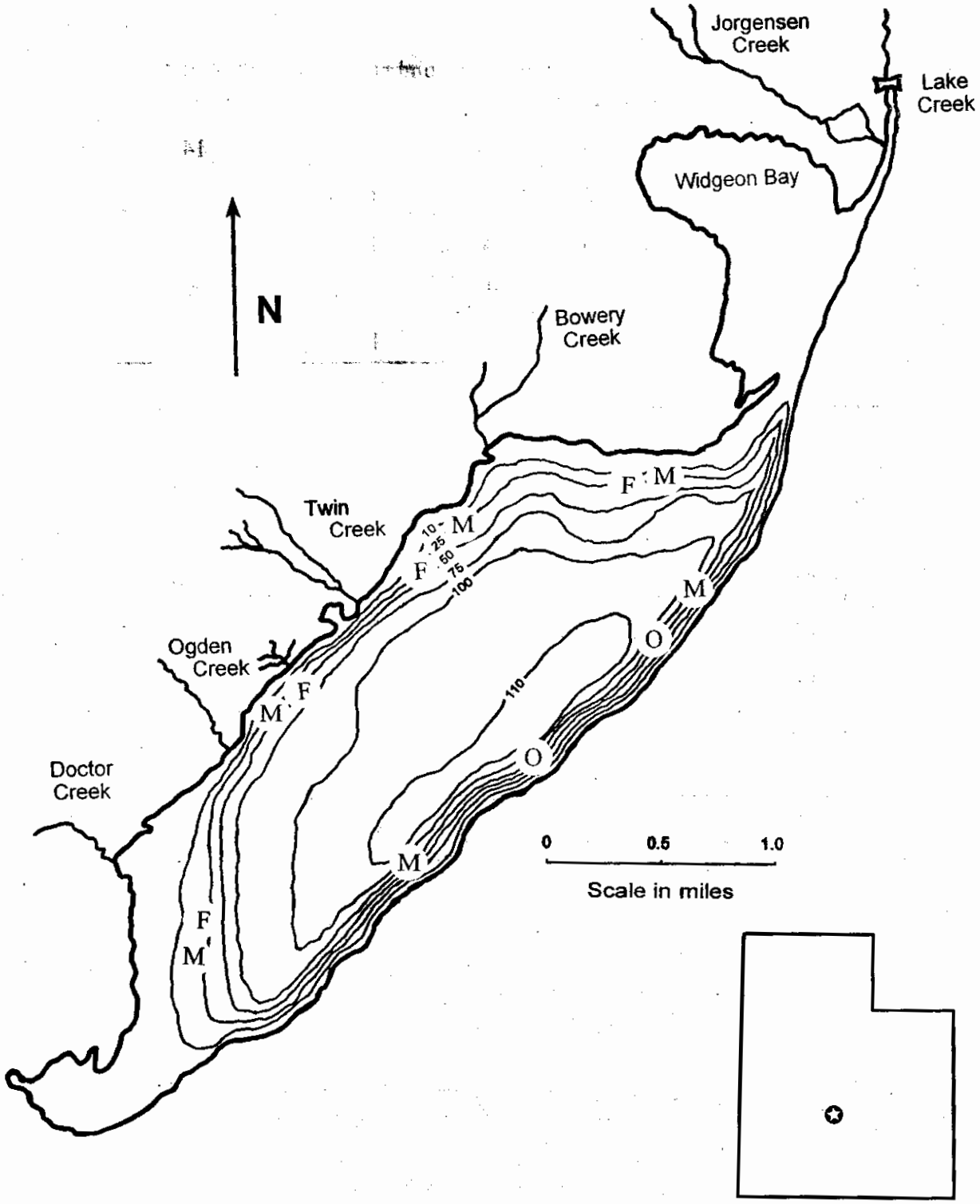

Figure 1. Map of Fish Lake showing the location of trend netting stations for spring, summer, and fall nettings (O = October spawning survey, M = May trend netting, and F = Forage netting).

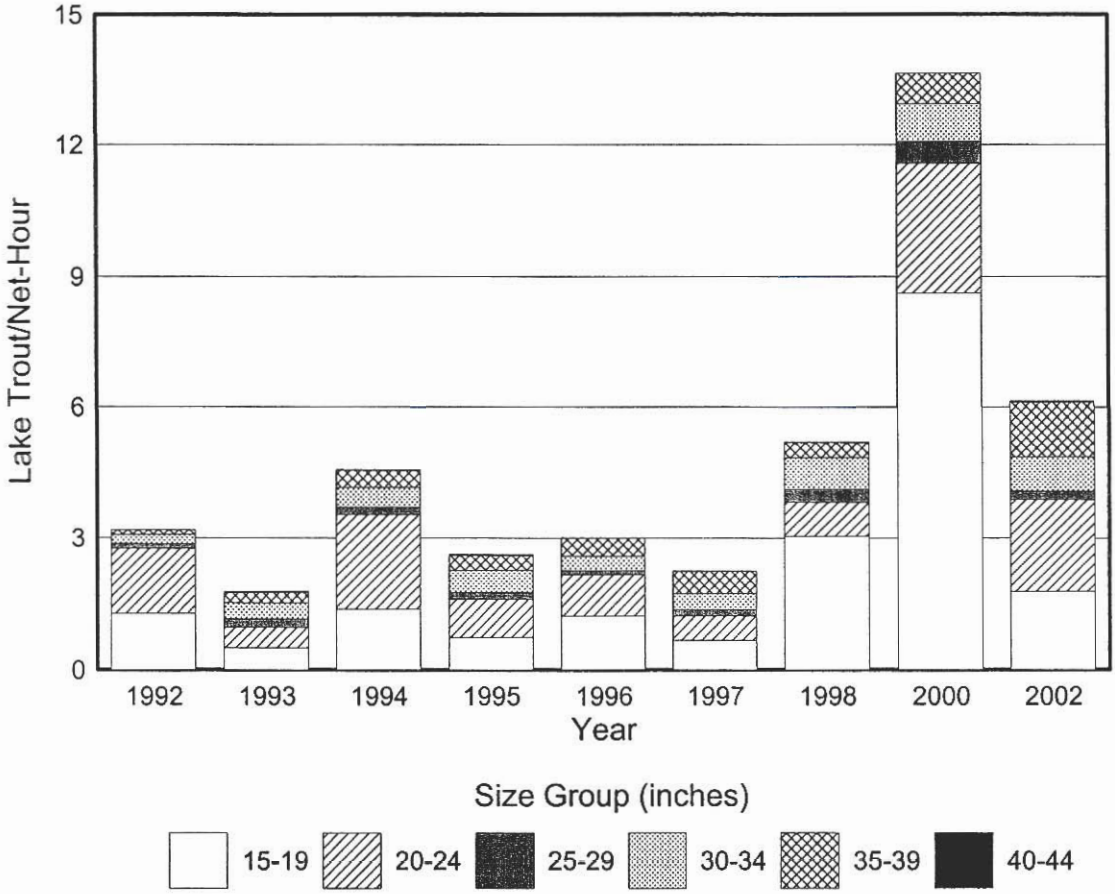

Figure 2. Catch rates of spawning lake trout captured at Fish Lake from 1992 to 2002, by size group.

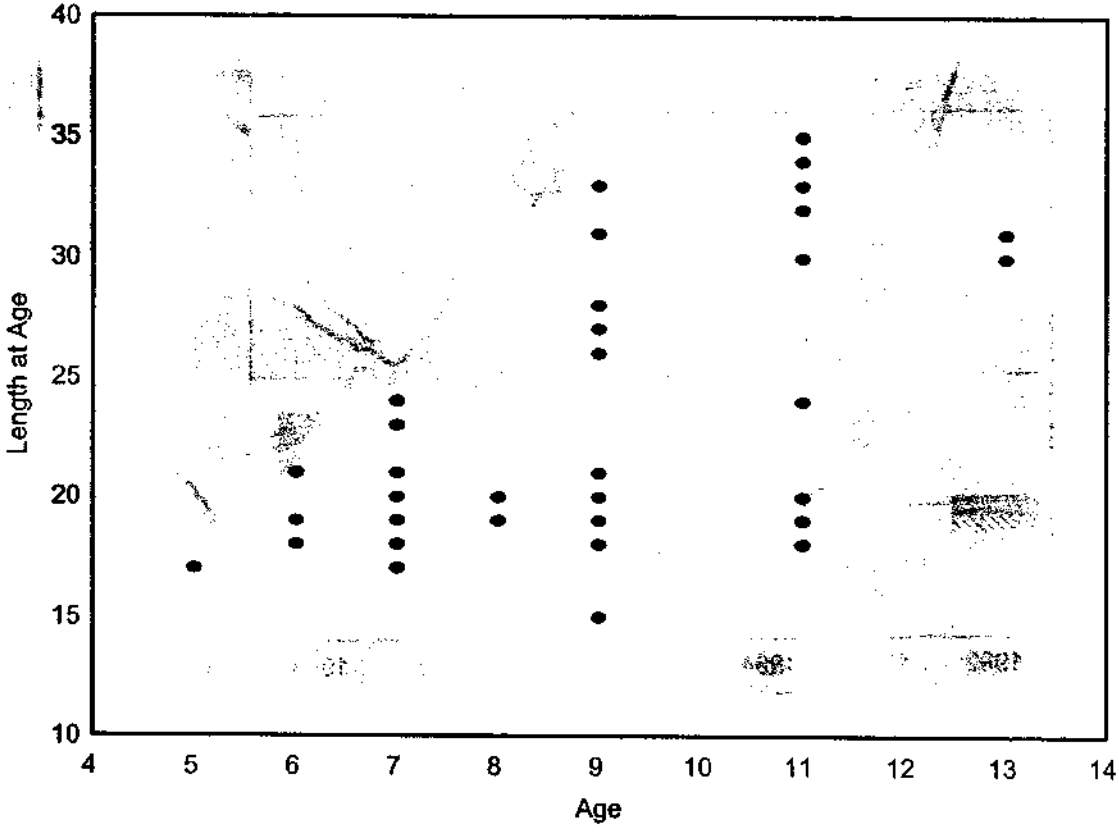

Figure 3. Variation in growth of marked lake trout captured at Fish Lake, Utah from 1996 to 2002, by age.